1. Introduction

Conference Co-Chairs:
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Through the Information Revolution Initiative of the US National Intelligence Council's (NIC's) Strategic Estimate Program, the US Government has undertaken a major study to chart the most likely course of the information revolution globally by 2020. The study is to encompass technical, business, financial, geopolitical, social, cultural, and national security issues. The study will take a total of three years and will draw heavily on several conferences. The results of this study will form a foundation that is likely to influence future research and various areas of government policy.

The RAND Corporation, because of its expertise in strategic planning, was tasked by the NIC to assist it in this initiative. RAND launched the study in November 1999 with a conference to assess trends in business, finance, governments, societies, and cultures driven by information technologies in various nations and regions of the world. The conference was attended by a broad cross-section of intellectual leaders from North America, Europe, and the Asia Pacific region. The main objectives of the conference were to: (1) Map out, region by region, key forces that will shape the information revolution, (2) Illustrate and explain differences between trends in the different regions, and (3) offer scenarios of information-technological futures for the regions. The proceedings of this conference (Hundley et al, 2000) have been published and were sent to participants in the conference being reported on here as background reading.

Objective of This "Technological Trends" Conference

On May 10-12, 2000, a second conference in this series was held at the University Club, Pittsburgh PA, with associated technology demonstrations and a reception at Carnegie Mellon University. The purpose of that conference, the subject of these proceedings, was to study the technology "drivers" of the information revolution. It sought to assess the effects of technologies already in

use and to speculate on the effects of new technologies that are likely to be put into practice by 2020. Forty-two invited participants attended, among whom were a number of information technology leaders from academia, industry and government. A breakdown of participants is shown in Fig. 1.1.
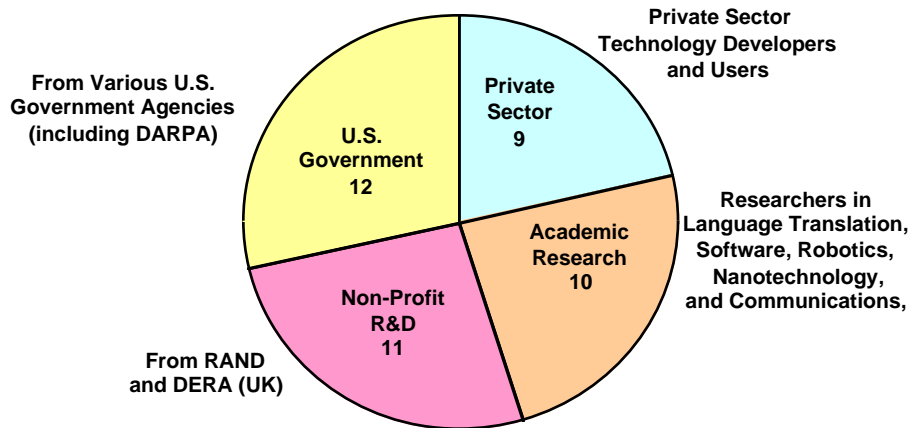

Figure 1..1 – Participants in Conference, by Affiliation

The conference addressed the important question of *how* IT systems will be *used* in the next twenty years. The notion of being used or practiced is very important for our purposes. Technologies that offer little value to people will not be used, no matter how interesting they are to their inventors. The most useful technologies are those that help solve major business, economic, communication, financial, and even cultural problems. The time has now passed when technologists can simply invent what they think will be useful. This is why the first conference -- to clarify the various contexts of use for information technology -- was held before this technology analysis conference.

Considerations on Attempting to Predict Future Developments

Predicting future actions of people is a risky exercise. Even so, some efforts have demonstrated competence at this and we can learn from them. We have sought to organize this conference to draw on competent prediction practice.

Methods of prediction, such as they are, fall into three broad categories:

- **Trend Extrapolation**, which examines the consequences of current realities; it works best when limited to 5-15 years in the future and breaks down for

longer projections because it does not account for how people react to the advancing trend.

- **"Reading the Clearing,"** which looks at the space of human practices -- historical, cultural, social, and technological. "Clearing" is a metaphor for a space in the forest, a space in which motion and action are possible; actions outside the limits of the "clearing" are not possible. This perspective reveals that technologies do not "drive" social change, but rather interact with social concerns, interests, and moods, producing changes in people's practices and ways of doing things. This perspective is more successful than any other method for projections beyond 20 years.[2]

- **Wishful Thinking**, which expresses hopes, fears or expectations about the future but offers little grounding for these opinions; it is perhaps the most popular of the three methods, and the least successful.

In 1893, as part of the Fourth Columbian Exposition, the Newspaper Guild invited 74 leaders of the day, from all walks of life, to speculate what the world would be like 100 years hence. Their essays were published in the newspapers in the weeks preceding the Exposition. In 1993, Historian Dave Walter resurrected these essays and collected them into a book called *Today Then*. What is most striking about this collection is how few of the predictions actually came to pass. Only 5 of the 74 authors discussed futures that resemble the world as we know it today. The others confidently predicted that technology would eliminate the distinctions between haves and have-nots, reduce postage to one cent, eliminate most crime, give people more time to advance their education, reduce taxation, and limit the scope of government. They predicted that the United States would encompass all of North America in about 60 states, that railroads would be the primary means of transportation, that pneumatic tubes would move people around cities and be used for transcontinental mail transport, and that aircraft would be limited to military uses. Only a few foresaw universal electric power and telephone, a communication system resembling the Internet, or a doubling of expected lifespan. No one foresaw world wars, the Interstate highway system, genetic engineering, mass state education, broadcast radio or TV, or the computer.

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[2] Herbert Dreyfus derived the metaphor "the clearing" from the work of the philosopher Martin Heidegger (Dreyfus, 1990). The "clearing" is the space of possible human action. Fernando Flores coined the metaphor "reading the world" to denote understanding how the world is moving (Spinoza, Dreyfus, and Flores, 1997). One of us (Denning) put these two slightly different contexts (world and clearing) into juxtaposition. Peter Drucker has used this approach in much of his recent work, but without giving it this name. (See, for example, Drucker, 1989.)

Looking back at the predictions of those leaders of yesteryear, we learn more about the kinds of observers they were than we do about our own day. We ask what were the assumptions they made that influenced their conclusions. We wonder what an observer 50 or 100 years from now will think of the predictions that come from this conference. We see in retrospect that most of their predictions were wishful thinking. A few of their predictions were trend extrapolations, all leading to the wrong conclusions. The five who "got it right" were all clearing-readers.

The task before us at this conference was to extrapolate trends over the next 15 years, which is about the empirical limit for extrapolations, and to read the clearing for predictions beyond that. We most definitely wanted to avoid wishful thinking. Consequently there is a lot of emphasis on understanding all the assumptions behind every forecast.

This conference used the ACM 97 Conference as a point of departure. See Denning and Metcalfe (1997) and Denning (1999) for collections of essays that summarize the visionary statements of industry leaders at that time. The ACM97 conference was a set of presentations, but there was no attempt to evaluate the credibility of each speculation or to reveal the key assumptions made by each speaker. We tried in this present conference to meet these two additional objectives.

Scope of Conference

The objective of the conference was to describe and understand -- to the extent possible -- the key developments in information-related technology -- artifacts, systems, and usage -- that could occur during the next 20 years. We focused on developments that might have major economic, social, cultural, or political impact, and attempted to take explicit account of possible differential impacts in different regions of the world. Accordingly, the conference concentrated on the topics summarized below as being of particular interest.

- Technology, artifacts, and developments in usage of information technology that facilitate access by those currently not "wired," such as those that avoid (or overcome) requirements for specialized training -- e.g., interfaces that do not depend on keyboard skills.

- Technologies and practices that remove (or overcome) language barriers.

- Technologies and practices that could accelerate the e-commerce paradigm and possibly lead to new business paradigms.

- Technologies and practices that could lead to new paradigms in education, medicine and health care, entertainment, and other societal areas.

   (Note: Entertainment is of particular interest because it is a medium through which social, political, and cultural values are transferred from one nation or generation to another.)

- Technologies and practices that couple cyberspace and physical space.

- Technologies and practices that favor new computing paradigms -- e.g., quantum computing, DNA-based computing, etc. What is the likelihood of any of these technologies being available by 2020? What would favor them? Inhibit them?

The agenda for the conference is shown in Appendix C. A list of participants and their affiliations is provided in Appendix B.

The Structure of This Report

The remainder of this report is organized as follows. Sections 2 and 3 summarize a set of "future visions" provided to an initial plenary session by several speakers in prepared remarks, and comments by a panel of observers reacting to these presentations and the assumptions underlying them.

The conference used four breakout sessions to explore various topics in more detail. The topic categories decided upon within the conference itself were:

- Technology trends and artifacts
- Services
- Markets
- Beyond cyberspace

(The last of these categories requires some explanation: Its charter was to explore the question: "What happens when information technology (IT) is ubiquitous – when cyberspace permeates social space?")

Sections 4-7 report on the deliberations and findings of these four breakout sessions.

Section 8 contains some comments on the results of the breakout sessions by another panel of observers, again attempting to probe behind the findings to

elucidate underlying assumptions, and to highlight possible missing topics and issues that weren't explored.

Section 9 presents some concluding remarks on the technology developments in the next 15-20 years that are likely to be particularly significant due to their broad impact.

Section 10 returns to the broader multi-year project of which this present exercise is a part, and discusses "what comes next" for the project.

In addition to the appendices mentioned above, we provide in Appendix A a white paper sent to conference participants afterward by Dr. David Farber of the University of Pennsylvania and the Federal Communications Commission. It contains succinct but useful commentary expanding on likely directions of the communications revolution and some of their implications.